01-03-99

A

Atty. Dkt. No. 15-XZ-4974 (70191/195)

12/29/99 JC490 U.S. PTO

12/29/99 09/474715 U.S. PTO

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Richard Aufrichtig et al.
Title:	CORRECTION OF DEFECTIVE PIXELS IN A DETECTOR
Appl. No.:	Unknown
Filing Date:	Unknown
Examiner:	Unknown
Art Unit:	Unknown

CERTIFICATE OF EXPRESS MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service's "Express Mail Post Office To Addressee" service under 37 C.F.R. § 1.10 on the date indicated below and is addressed to: **Assistant Commissioner for Patents, Washington, D.C. 20231.**

EL529676391US 12-29-1999
(Express Mail Label Number) (Date of Deposit)

SANDRA MURPHY
(Printed Name)

Sandra Murphy
(Signature)

UTILITY PATENT APPLICATION TRANSMITTAL

Assistant Commissioner for Patents
Box PATENT APPLICATION
Washington, D.C. 20231

Sir:

Transmitted herewith for filing under 37 C.F.R. § 1.53(b) is the nonprovisional utility patent application of:

Richard Aufrichtig
Ping Xue
Kenneth Scott Kump

Enclosed are:

[**X**] Specification, Claim(s), and Abstract (16 pages).

[**X**] Informal drawings (6 sheets, Figures 1-9).

[**X**] Declaration and Power of Attorney (6 pages).

[**X**] Assignment of the invention to GE Medical Systems Global Technology Company, LLC.

[**X**] Assignment Recordation Cover Sheet.

[ ] Check in the amount of $40.00 for Assignment recordation.

[ ] Small Entity statement.

[ ] Information Disclosure Statement.

[ ] Form PTO-1449 with copies of ___ listed reference(s).

The filing fee is calculated below:

	Claims as Filed		Included in Basic Fee		Extra Claims		Rate		Fee Totals
Basic Fee							$690.00		$690.00
Total Claims:	28	-	20	=	8	x	$18.00	=	$144.00
Independents:	3	-	3	=	0	x	$78.00	=	$0.00
If any Multiple Dependent Claim(s) present:						+	$260.00	=	$0.00
							SUBTOTAL:	=	$834.00
[ ]	Small Entity Fees Apply (subtract ½ of above):							=	$0.00
							TOTAL FILING FEE:	=	$834.00

[ ] A check in the amount of –0- to cover the filing fee is enclosed.

[ ] The required filing fees are not enclosed but will be submitted in response to the Notice to File Missing Parts of Application.

[**X**] The Assistant Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 07-0845. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Assistant Commissioner is authorized to charge the unpaid amount to Deposit Account No. 07-0845.

Please direct all correspondence to the undersigned attorney or agent at the address indicated below.

Respectfully submitted,

Date 12/29/1999

By Katherine Lee

FOLEY & LARDNER
Firstar Center
777 East Wisconsin Avenue
Milwaukee, Wisconsin 53202-5367
Telephone: (414) 297-5531
Facsimile: (414) 297-4900

Katherine D. Lee
Attorney for Applicant
Registration No. 44,865

15-XZ-4974

U. S. PATENT APPLICATION

for

CORRECTION OF DEFECTIVE PIXELS IN A DETECTOR

Inventors: Richard Aufrichtig
Ping Xue
Kenneth S. Kump

70191/195
001.628677.2

CORRECTION OF DEFECTIVE PIXELS IN A DETECTOR

BACKGROUND OF THE INVENTION

The present invention relates generally to detector systems. More particularly, the present invention relates to a detector system equipped to correct defective pixel values therein.

A solid state detector contains a plurality of photodetector elements. For example, a radiographic x-ray detector can include several million photodetector elements to correspondingly provide an image having several million pixels. Such a detector typically comprises a scintillating layer in contact with an array of photodiodes arranged in rows and columns. Each photodiode converts impinging light into an electrical charge or signal proportional thereto, and in turn, each electrical signal is processed and converted into a digital value. The resulting array of digital valves comprise the image data for the image to be displayed.

In the course of manufacturing such a detector, a certain number of photodetector elements will invariably be defective. Because pixel size is chosen such that objects of interest in the image will be greater than the size of an individual pixel, a perfect detector is not required for imaging. However, if defective or bad pixels are aggregated in sizeable clusters, the loss of relevant information may be considerable. Alternatively, since defective pixel values would either be independent of the impinging light, because the corresponding detector locations are not photonically and/or electrically responsive, or be dependent of the impinging light but in manner statistically different from its neighboring pixels, if defective pixels are left unaltered in the displayed image, they would distract from the visualization of the rest of the image.

Presently, there are known methods for identifying and correcting defective pixel values prior to displaying the image. These correction methods replace each defective pixel value with an interpolation of its neighboring pixel values. Such correction methods, however, are quite susceptible to creating image

artifacts, such as breaks in guide wires, because the correction relies only on the defective pixel's surrounding pixels, i.e., the eight pixels surrounding the defective pixel.

Thus, there is a need for a correction method that provides a more accurate correction of defective pixels. Further, there is a need for an apparatus and method configured to utilize image feature information to perform defective pixel correction.

BRIEF SUMMARY OF THE INVENTION

One embodiment of the invention relates to a method for correcting a defective pixel in an image produced by a detector. The image includes an array of pixels and the array of pixels has a corresponding array of pixel values. The method includes determining a local gradient, the local gradient comprising an array of local gradient matrix elements. The method further includes providing a correction value based on the local gradient to correct the defective pixel.

Another embodiment of the invention relates to a system for correcting a defective pixel in an image produced by a detector. The system includes a processor coupled to the detector, the processor configured to determine a local gradient and to generate a correction value based on the local gradient. The image includes an array of pixels, each pixel having a corresponding pixel value, and the local gradient comprises an array of local gradient matrix elements.

Still another embodiment of the invention relates to a system for correcting a defective pixel in an image produced by a detector. The image includes an array of pixels, the array of pixels having a corresponding array of pixel values. The system includes means for determining a local gradient, the local gradient comprising an array of local gradient matrix elements. The system further includes means for providing a correction value based on the local gradient to correct the defective pixel.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiment will become more fully understood from the following detailed description, taken in conjunction with the accompanying drawings, wherein like reference numerals denote like elements, in which:

FIG. 1 is a block diagram of a solid state detector imaging system which employs an embodiment of the present invention;

FIG. 2 is a cross-sectional view of a detector which comprises a portion of the solid state detector imaging system of FIG. 1;

FIG. 3 is a flowchart of a defective pixel correction scheme implemented in the solid state defector system of FIG. 1;

FIG. 4 is a sample image with no defective pixels;

FIG. 5 is a sample map of defective pixels;

FIG. 6 is a sample image using a conventional correction method;

FIG. 7 is a sample image using an embodiment of the defective pixel correction scheme of the present invention;

FIG. 8 is a sample map of pixel differences between the image with no defective pixels of FIG. 4 and the image using the conventional correction method of FIG. 6; and

FIG. 9 is a sample map of pixel differences between the image with no defective pixels of FIG. 4 and the image using an embodiment of the present invention of FIG. 7.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, there is shown the major components of a solid state detector imaging system 10. System 10 includes a detector 12, a readout

electronics 18, a scan electronics 24, a processor 20, and an operator console 30. System 10 is configured to sense photonic energy 34 impinging on the detector 12 and to display an image corresponding to the intensity of such photonic energy on a display device (CRT, LCD, etc.) of the operator console 30. Photonic energy 34 impinges on detector 12, and detector 12 outputs analog signals corresponding to the intensity or energy of photonic energy 34 to readout electronics 18. Readout electronics 18 is coupled to processor 20, and processor 20 is coupled to operator console 30. Scan electronics 24 is coupled to detector 12.

In one embodiment, system 10 is configured to be a x-ray detection imaging system. X-rays are provided by a source and travel through a collimator, to be attenuated by a subject of interest to be imaged, i.e., a patient. Then photonic energy 34 (which in this case are the attenuated x-rays) is received by detector 12 for image display (not shown).

Referring to FIG. 2, detector 12 includes a scintillator 14 and an array of photodetector elements 22. Scintillator 14 converts photonic energy 34 from x-rays to light 16 at wavelengths receivable by photodetector elements 22. For example, scintillator 14 may be comprised of thallium (Tl) doped cesium iodide (CsI) that converts x-rays into visible light. Impinging light 16 is converted into an array of electrical signals by corresponding photodetector elements 22. Although not shown, detector 12 may comprise more than one detector.

Each of photodetector elements 22 includes a photodiode comprised of thin film materials, such as amorphous silicon, and a thin film field effect transistor (not shown). In this manner, each of photodetector elements 22 is configured to output an electrical signal proportional to photonic energy 34 impinging thereon to readout electronics 18 and to be controlled by scan electronics 24, such as being "reset" to acquire the next image.

The readout electronics 18 are configured to convert the array of electrical signals, i.e., analog signals, into an array of digital signals that can be

processed, stored, and displayed as an image using processor 20 and operator console 30. Alternatively, the digitization of the electrical signals can occur in processor 20. Moreover, in order to reduce the amount of readout electronics 18 required in system 10, photodetector elements 22 can be configured to store the electrical signals until they can be processed by readout electronics 18.

Processor 20 is configured to provide electrical signal processing, into an image data form suitable for image display, storage, transmission to a remote site, film or print record, or other utilization and manipulations. Such processing may include performing defective pixel correction (as described in greater detail hereinafter). Operator console 30 includes various components such as a display device, a storage device, a printer, and an operator control unit (e.g., a mouse, a keyboard, a graphical user interface, etc. (not shown)) to facilitate various utilization and manipulation of the acquired image data. Alternatively, operator console 30 may be omitted and the various output modes of the acquired image data may be carried out in processor 20.

Detector 12 includes a plurality of photodetector elements 22. Depending on factors such as the type of desired imaging, resolution, cost of system, etc., detector 12 can vary in size and construction. For example, for x-ray imaging relatively large portions of the test subject, such as the patient's chest area, a 41 x 41 cm^2 active area detector can include several million photodetector elements 22 (e.g., 2048 x 2048 array of photodetector elements 22) with a pixel pitch of 200 x 200 μm^2. As another example, detector 12 may have a smaller active area for use in mammography and have a 100 x 100 μm^2 pixel pitch. In still another example, detector 12 may be housed inside a charge-coupled device (CCD) camera with an active area of only 2 cm^2.

Moreover, it should be understood that system 10 is not limited to x-ray imaging. In another embodiment, system 10 can be configured to acquire images from photonic energy 34 outside the wavelengths of x-rays. Accordingly,

detector 12 may include additional components, or components such as scintillator 14 can be omitted.

Because detector 12 includes a large number of photodetector elements 22, it is not unusual for one or more photodetector elements 22 to be defective. Such photodetector elements 22 are defective because they are not responding photonically or electrically, or because they respond electrically but in a manner statistically different from other photodetector elements 22 with similarly impinged photonic energy 34. Consequently, defective photodetector elements 22 produce defective electrical signals and ultimately defective pixel values in the displayed image, if left unaltered. While it may be unpractical and expensive to refabricate defective photodetector elements 22, it is possible to correct or mask defective pixel values before the acquired image is displayed.

Before such a correction scheme is implemented, defective pixels of detector 12 are identified using one or more conventionally known methods. For example, during calibration and setup of system 10, all the defective pixels of detector 12 can be identified by analyzing known images, e.g., an image containing no structure, and searching for nonconforming or unexpected pixel values. For more details relating to identification of defective pixels, reference is made to U.S. Pat. No. 5,657,400 owned by the General Electric Company, which is incorporated herein by reference. From this identification step, n number of defective pixels can be identified for detector 12.

After a current image has been acquired using detector 12, each defective pixel i in the current acquired image, where $i = 1, 2, \ldots, n$, can be corrected or masked. Referring to FIG. 3, there is shown a flowchart of an image feature or gradient method for correcting defective pixel values. The correction scheme preferably occurs in processor 20 after the array of electrical signals have been converted into digital signals. The correction scheme includes a temporarily replace defective pixel step 42, a select matrices step 44, a determine local gradient step 46, a determine correction value step 48, a replace defective pixel value step

50, a check step 52, and an incrementor step 54. For each defective pixel *i*, steps 42-54 are carried out to provide a correction thereto.

In step 42, the value of defective pixel *i* is temporarily replaced with a linear interpolation of its surrounding neighboring pixel values. Details relating to linear interpolation are provided in U.S. Pat. No. 5,657,400, which has already been incorporated herein by reference. Alternatively, step 42 may be omitted and the correction may be performed without determining the linear interpolation of defective pixel *i*.

After step 42, the selection of matrices A_i and H are carried out in step 44. A_i is a matrix of the pixel values comprising the acquired image with the value of defective pixel *i* temporarily replaced by t_i (in step 42). In the case of a detector 12 including 2048 x 2048 array of photodetector elements 22, A_i can be up to a 2048 x 2048 matrix. Alternatively, A_i can be smaller than a 2048 x 2048 matrix, comprised of t_i, as the center matrix element, and its surrounding neighboring pixels as the remaining matrix elements. For example, A_i may be a 7x7 matrix.

H is a gradient kernel matrix. In one embodiment, H is a 7x7 Laplacian of a Gaussian filter kernel defined by the values:

$$H = \begin{matrix} 0.0235 & 0.0235 & 0.0235 & 0.0235 & 0.0235 & 0.0235 & 0.0235 \\ 0.0235 & 0.0235 & 0.0256 & 0.0355 & 0.0256 & 0.0235 & 0.0235 \\ 0.0235 & 0.0256 & 0.3034 & 0.7128 & 0.3034 & 0.0256 & 0.0235 \\ 0.0235 & 0.0355 & 0.7128 & -5.0694 & 0.7128 & 0.0355 & 0.0235 \\ 0.0235 & 0.0256 & 0.3034 & 0.7128 & 0.3034 & 0.0256 & 0.0235 \\ 0.0235 & 0.0235 & 0.0256 & 0.0355 & 0.0256 & 0.0235 & 0.0235 \\ 0.0235 & 0.0235 & 0.0235 & 0.0235 & 0.0235 & 0.0235 & 0.0235 \end{matrix}$$

In another embodiment, H can be of a different matrix size, such as 11x11 or 5x5. Moreover, H can be a variety of gradient kernels, such as a Roberts, Prewitt, or Sobel gradient kernel. It shall be understood that the matrix size of A_i and the matrix type and size of H can be preset such that step 44 may be omitted.

The selection capability in step 44 provides flexibility in noise immunity vs. edge strength.

After step 44, determination of a local gradient, G_i around temporarily replaced pixel t_i is carried out in step 46. In one embodiment, G_i is calculated by:

$$G_i = \sqrt{(A_i * H)^2 + (A_i * (-H))^2}$$

For example, when A_i and H are both 7x7 matrices, G_i will be a 7x7 matrix. Alternatively, G_i can be determined by a variety of other equations such that G_i provides relative gradient information about the pixels surrounding defective pixel *i* (the surrounding pixels as specified by A_i) with respect to image features, such as a strong edge, embodied by these surrounding pixels. Thus the matrix elements of G_i having the highest values, i.e., strongest gradients, correspond to pixels comprising the strongest image features for that portion of the image.

Using G_i calculated in step 46, a correction value c_i to correct defective pixel *i* is determined in step 48. Correction value c_i is a linear average or a weighted average of the *i*th defective pixel's surrounding neighboring pixel values with the highest gradients and/or closest proximity to defective pixel *i*. Correction value c_i insures that defective pixel *i* is replaced with image information along an image gradient, i.e. based on more global image information such as image features, instead of very local image information only. Any well-known linear averaging or weighted averaging methods can be utilized to determine c_i.

For example, step 48 can comprise a weighted average based on the three highest gradient pixel values within a three-pixel radius of defective pixel *i*. Then the pixel values corresponding to the highest, the second highest, and third highest gradient pixel, respectively, would be given a weight of 50%, 30%, and 20%, respectively. In another example, step 48 can comprise a weighted average based on the three highest gradient pixel values within a three-pixel radius of defective pixel *i* with greater weight given to pixels closer in location to defective

pixel i. Assume that for these three highest gradient pixels, one pixel is located at each of one-pixel, two-pixel, and three-pixel radius of defective pixel i. Then the pixel values located at the one-pixel, two-pixel, and three-pixel radius of defective pixel i, respectively, would be given a weight of 50%, 30%, and 20%, respectively.

Once c_i has been determined in step 48, the value of defective pixel i (actually t_i from step 42) is replaced with the correction value c_i in step 50. If all the defective pixels in a given image have not been corrected (i.e., $i < n$), then step 52 directs the defective pixel correction to be performed for the next defective pixel (i.e., $i = i + 1$ in step 54). Otherwise if all the defective pixels in a given acquired image have been corrected (i.e., $i = n$), then step 52 directs the defective pixel correction process to end for this acquired image. Thus the final image, to be displayed, printed, etc., is the acquired image with correction of its defective pixels.

In FIGs. 4-9, an illustrative comparison of a final image generated using a conventional correction method and a final image generated using an embodiment of the present invention is provided. FIG. 4 is an image containing no defective pixels. The image includes, with respect to the background, a first circle 60 having positive contrast and a second circle 80 having a negative contrast. In FIG. 5, a map of a plurality of defective or bad pixels 62, 82 is shown. Defective pixels 62, 82 are introduced or merged with first and second circles 60, 80, respectively, to form the start or "acquired" image. The defective pixels of this start or "acquired" image are corrected (e.g., the defective pixel map shown in FIG. 5) to generate the final image, using (a) a conventional correction method such as linear interpolation (in FIG. 6), or (b) an embodiment of the gradient method (in FIG. 7).

The advantage of using the gradient method over the conventional method is readily apparent in FIGs. 8 and 9. FIG. 8 shows the pixel differences between the image containing no defective pixels (FIG. 4) and the image corrected with the conventional method (FIG. 6). Similarly, FIG. 9 shows the pixel differences between the image containing no defective pixels (FIG. 4) and the image

corrected with the gradient method (FIG. 7). Thus, the gradient method results in a much smaller number of deviating pixels, i.e., insufficiently corrected or not corrected pixels, than the conventional method. Moreover, the gradient method is better capable of preserving image features and edges, such as features 64, 84 (see FIG. 6), than the conventional method, such as features 66, 86 (see FIG. 7).

While the embodiments and application of the invention illustrated in the FIGs. and described above are presently preferred, it should be understood that these embodiments are offered by way of example only. For example, it is contemplated that the invention may be applied to systems other than medical systems which can benefit from the use of defective pixel correction. Still further, the present invention may be implemented using hardware, software, and/or firmware. Even still further, the correction values of the defective pixels (i.e., c_i) can be linked with its acquired image in a variety of manner, such as permanently replacing the defective pixel values on the acquired image or separately storing the correction values with links to the corresponding defective pixel locations. Accordingly, the present invention is not limited to a particular embodiment, but extends to various modifications that nevertheless fall within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method for correcting a defective pixel in an image produced by a detector, the image including an array of pixels and the array of pixels having a corresponding array of pixel values, comprising:

(a) determining a local gradient, the local gradient comprising an array of local gradient matrix elements; and

(b) providing a correction value based on the local gradient to correct the defective pixel.

2. The method of claim 1, wherein step (a) of determining a local gradient includes determining the local gradient in part from a gradient kernel and at least a portion of the array of pixel values.

3. The method of claim 2, wherein the at least a portion of the array of pixel values comprises a matrix, and includes the defective pixel as a center matrix element and a surrounding neighboring pixels of the defective pixel as remaining matrix elements.

4. The method of claim 2, further comprising:

selecting a matrix size of the at least a portion of the array of pixel values; and

selecting the gradient kernel from a group including a Laplacian of a Gaussian filter kernel, a Roberts gradient kernel, a Prewitt gradient kernel, and a Sobel gradient kernel.

5. The method of claim 1, wherein step (b) of providing a correction value includes at least one of a linear interpolation and a weighted average of pixel values corresponding to the highest local gradient matrix elements.

6. The method of claim 5, wherein the highest local gradient matrix elements include at least three highest local gradient matrix elements.

7. The method of claim 5, wherein the weighted average of pixel values having the highest local gradient matrix elements include giving greater weight to pixel values proximate to the defective pixel.

8. The method of claim 1, further comprising:

identifying the defective pixel in the image produced by the detector before the determining step (a);

replacing temporarily the defective pixel with a linear interpolation of a surrounding neighboring pixels of the defective pixel before the determining step (a); and

replacing the defective pixel with the correction value after the providing step (b).

9. The method of claim 1, further comprising repeating steps (a)-(b) a plurality of times as desired to correct a plurality of defective pixels in the image produced by the detector.

10. A system for correcting a defective pixel in an image produced by a detector, comprising:

a processor coupled to the detector, the processor configured to determine a local gradient and to generate a correction value based on the local gradient, wherein the image includes an array of pixels, each pixel having a corresponding pixel value, and the local gradient comprising an array of local gradient matrix elements.

11. The system of claim 10, wherein the processor is configured to determine the local gradient partly from a gradient kernel and at least a portion of the array of pixel values.

12. The system of claim 11, wherein the at least a portion of the array of pixel values comprises a matrix, and includes the defective pixel as a center matrix element and a surrounding neighboring pixels of the defective pixel as remaining matrix elements.

13. The system of claim 11, further comprising an operator console coupled to the processor and configured to select a matrix size of the at least a portion of the array of pixel values and to select the gradient kernel from a group including a Laplacian of a Gaussian filter kernel, a Roberts gradient kernel, a Prewitt gradient kernel, and a Sobel gradient kernel.

14. The system of claim 10, wherein the correction value comprises at least one of a linear interpolation and a weighted average of pixel values having the highest local gradient matrix elements.

15. The system of claim 14, wherein the highest local gradient matrix elements include at least three highest local gradient matrix elements.

16. The system of claim 15, wherein the weighted average of pixel values having the highest local gradient matrix elements include providing greater weight to pixels proximate to the defective pixel.

17. The system of claim 10, wherein the detector comprises an array of photodetector elements, each photodetector element configured to convert an impinging photonic energy into an electrical signal proportional thereto.

18. The system of claim 10, wherein the processor is configured to determine the local gradient and to generate the correction value for each of a plurality of defective pixels in the image produced by the detector.

19. A system for correcting a defective pixel in an image produced by a detector, the image including an array of pixels, the array of pixels having a corresponding array of pixel values, comprising:

(a) means for determining a local gradient, the local gradient comprising an array of local gradient matrix elements; and

(b) means for providing a correction value based on the local gradient to correct the defective pixel.

20. The system of claim 19, wherein the local gradient is determined in part from a gradient kernel and at least a portion of the array of pixel values.

21. The system of claim 20, wherein the at least a portion of the array of pixel values comprises a matrix, and includes the defective pixel as a center matrix element and a surrounding neighboring pixels of the defective pixel as remaining matrix elements.

22. The system of claim 20, further comprising means for selecting a matrix size of the at least a portion of the array of pixel values and means for selecting the gradient kernel from a group including a Laplacian of a Gaussian filter kernel, a Roberts gradient kernel, a Prewitt gradient kernel, and a Sobel gradient kernel.

23. The system of claim 19, wherein the correction value comprises at least one of a linear interpolation and a weighted average of pixel values having the highest local gradient matrix elements.

24. The system of claim 23, wherein the highest local gradient matrix elements include at least three highest local gradient matrix elements.

25. The system of claim 23, wherein the weighted average of pixel values having the highest local gradient matrix elements include providing greater weight to pixels proximate to the defective pixel.

26. The system of claim 19, wherein the means for determining and the means for providing include determining the local gradient and generating the correction value, respectively, for each of a plurality of defective pixels in the image produced by the detector.

27. The system of claim 19, further comprising:

means for temporarily replacing the defective pixel with a linear interpolation of a surrounding neighboring pixels of the defective pixel before the local gradient is determined; and

means for replacing the defective pixel with the correction value.

28. The system of claim 27, wherein the means for replacing includes at least one of replacing the defective pixel with the correction value, and storing the correction value with an identifying link to the defective pixel in a storage device.

CORRECTION OF DEFECTIVE PIXELS IN A DETECTOR

ABSTRACT OF THE DISCLOSURE

A detector imaging system having an apparatus and method for correcting defective pixels in an acquired image is disclosed herein. The system includes a correction scheme including temporarily replacing a defective pixel with a linear interpolation of the defective pixel's surrounding neighboring pixel values, determining a local gradient based in part on the acquired image and a gradient kernel, and providing a correction value based on the local gradient to correct the defective pixel. The correction scheme is repeated a plurality of times as desired to correct all the defective pixels in the acquired image.

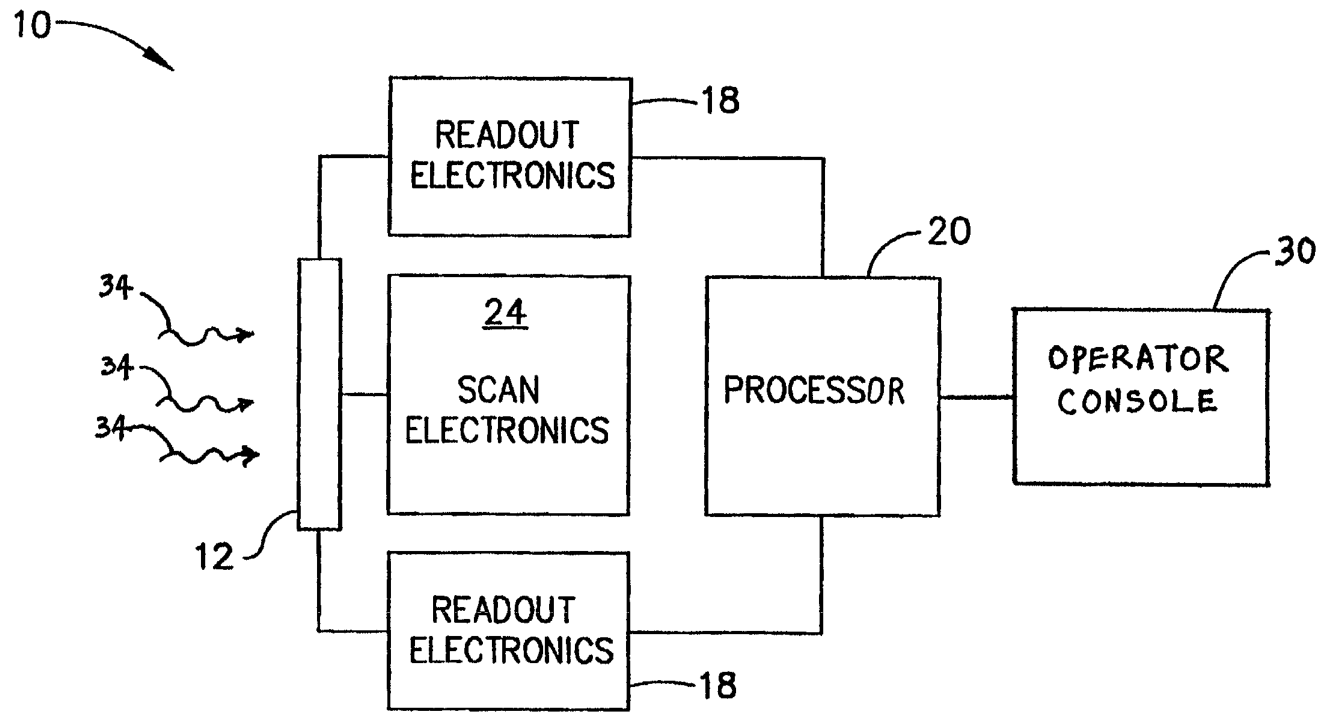

10
34
34
34
12
READOUT ELECTRONICS
18
24
SCAN ELECTRONICS
READOUT ELECTRONICS
18
PROCESSOR
20
OPERATOR CONSOLE
30

FIG. 1

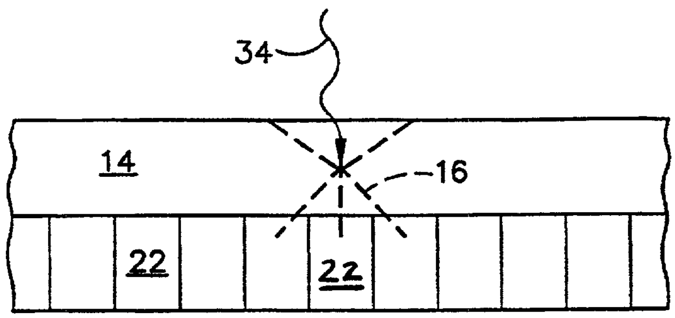
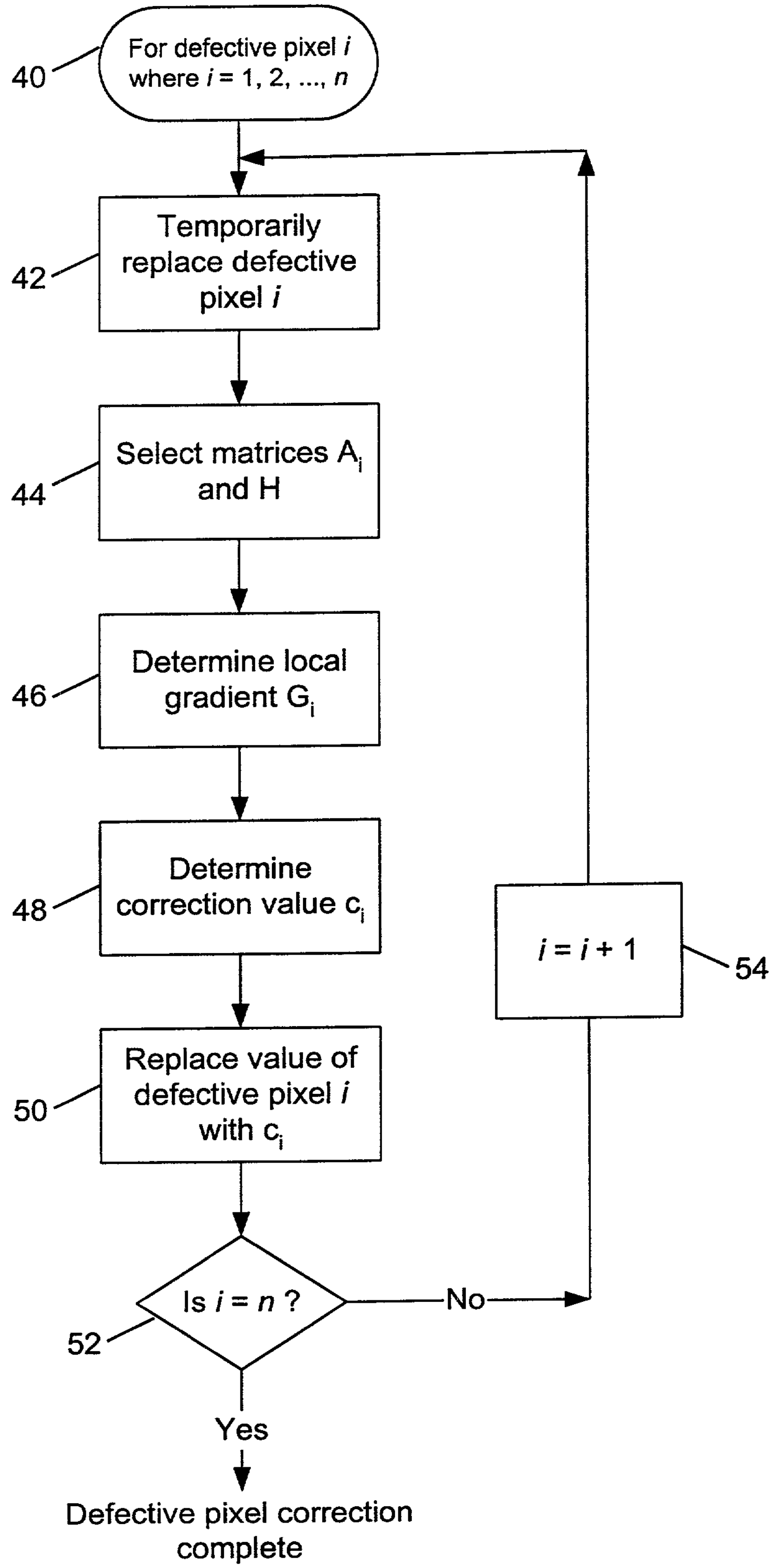


FIG. 2



40
For defective pixel i where i = 1, 2, ..., n
42
Temporarily replace defective pixel i
44
Select matrices A_i and H
46
Determine local gradient G_i
48
Determine correction value c_i
50
Replace value of defective pixel i with c_i
52
Is i = n ?
No
i = i + 1
54
Yes
Defective pixel correction complete

FIG. 3

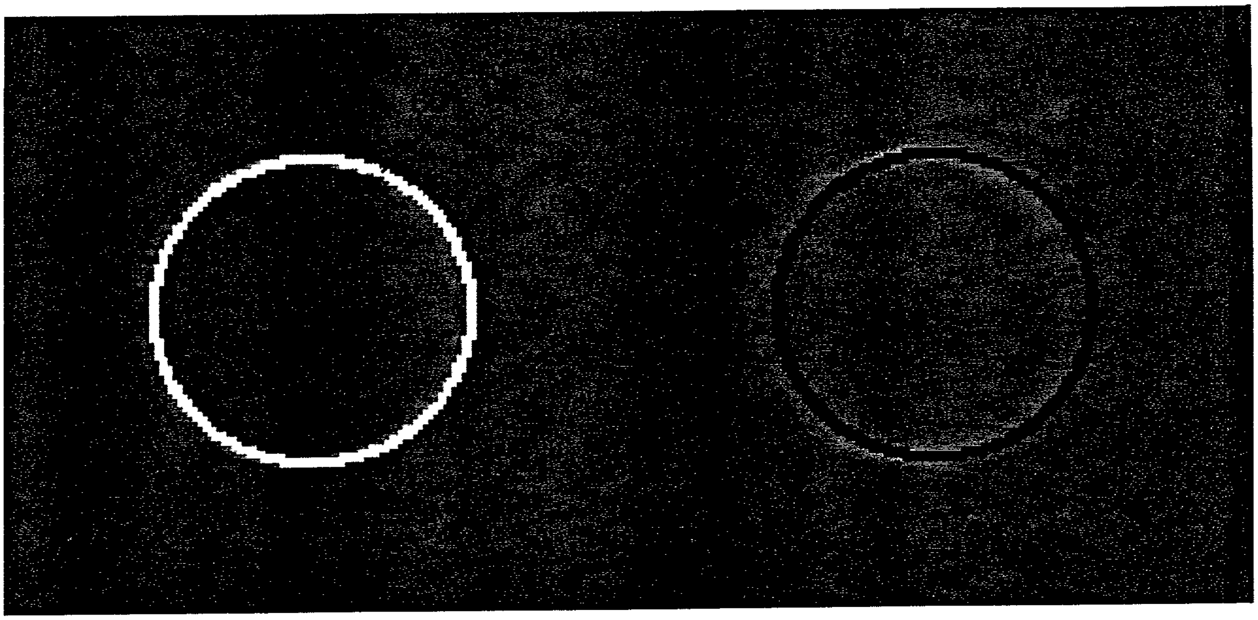


FIG. 4

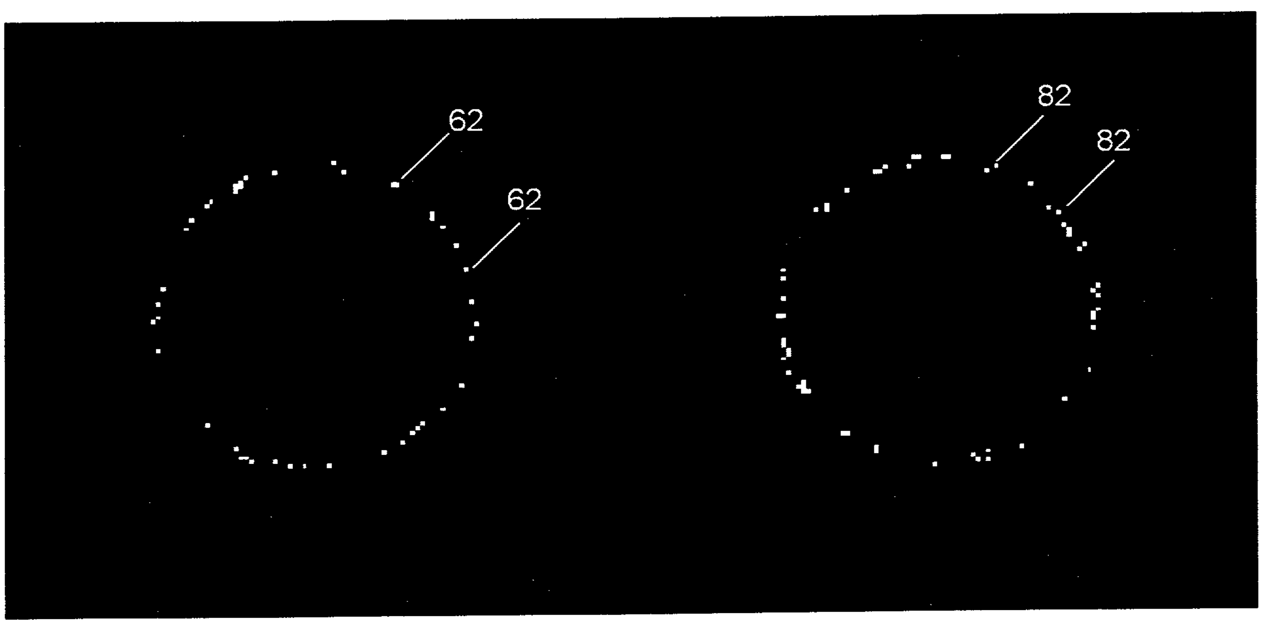


FIG. 5

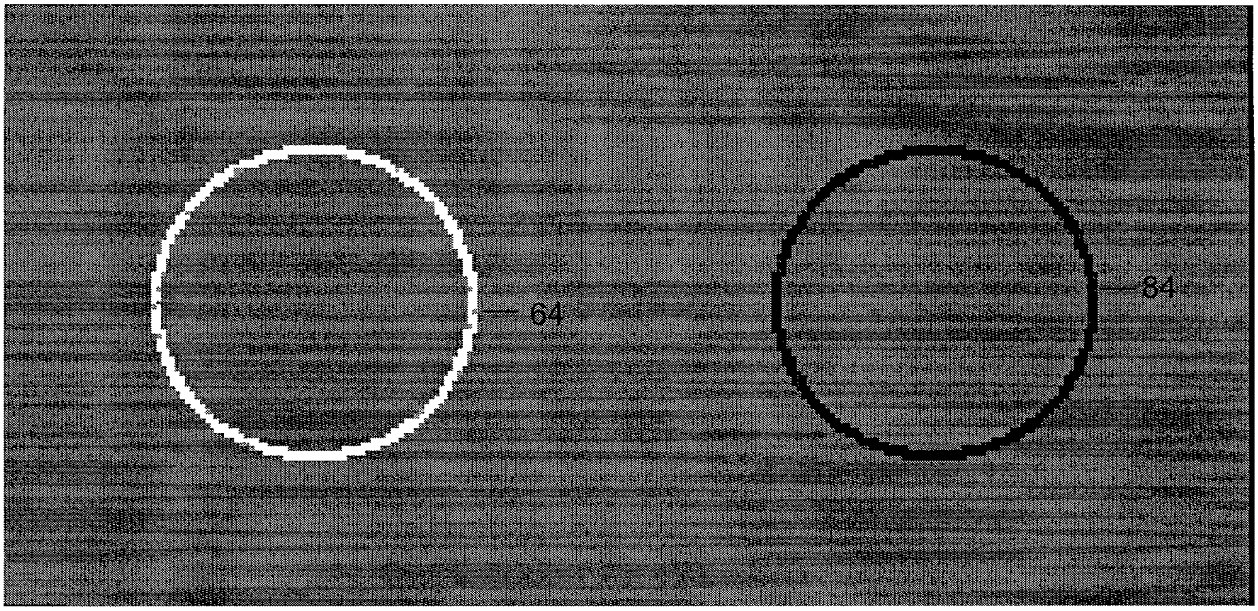


FIG. 6

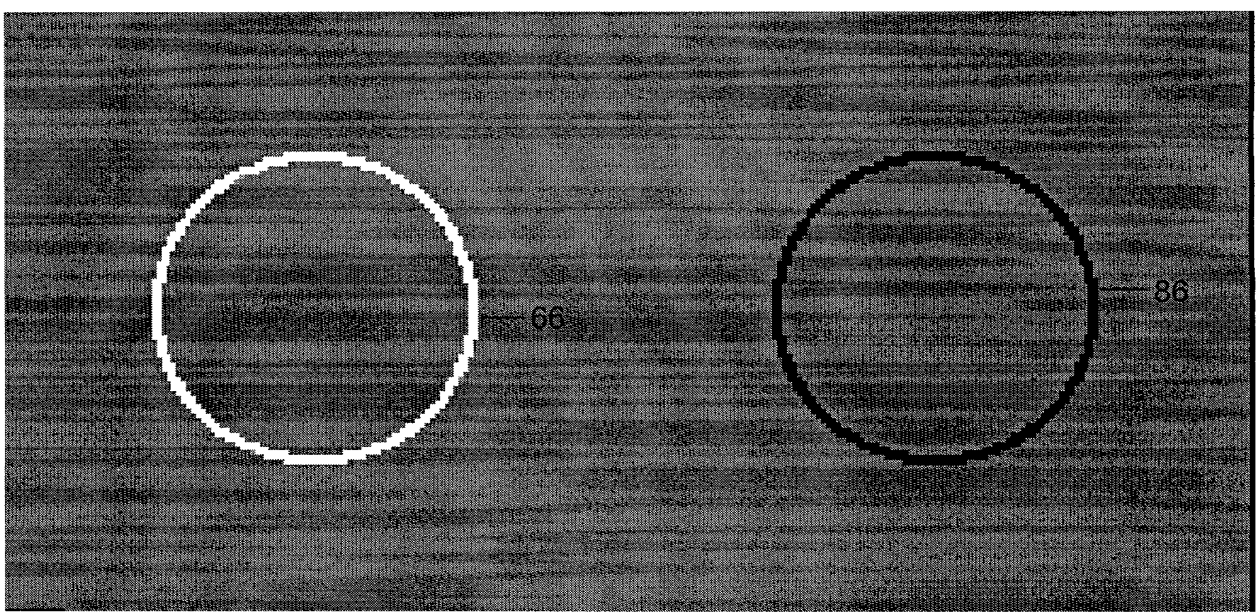


FIG. 7

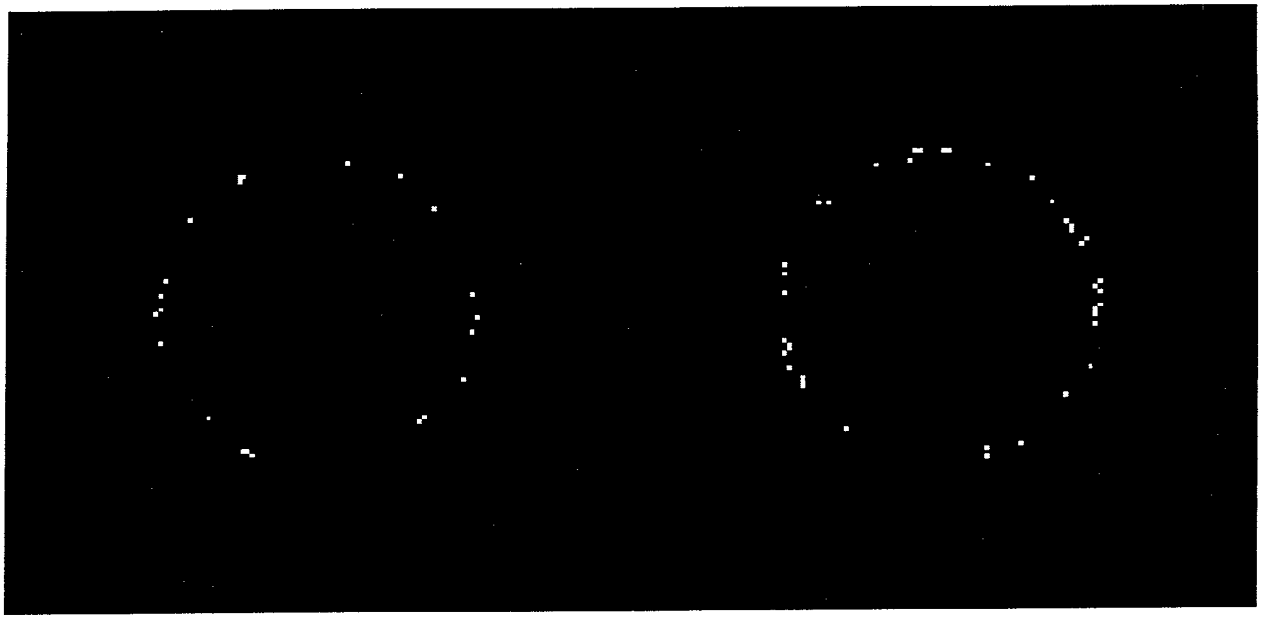


FIG. 8

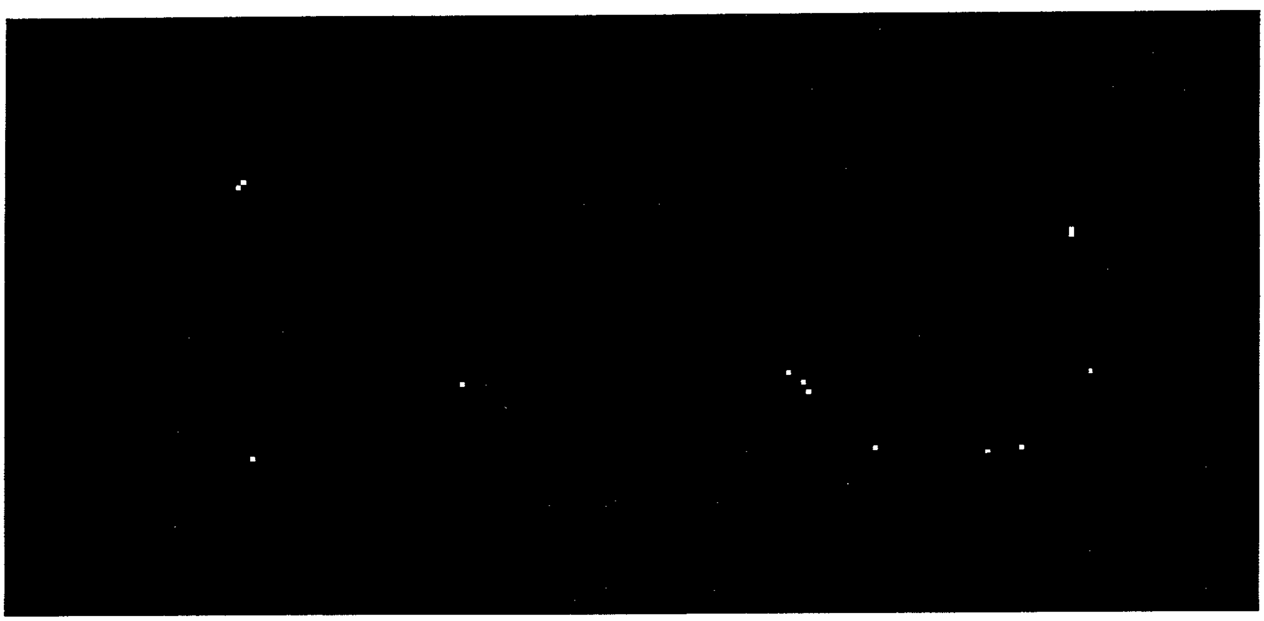


FIG. 9

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I HEREBY DECLARE:

THAT my residence, post office address, and citizenship are as stated below next to my name;

THAT I believe I am the original, first, and sole inventor (if only one inventor is named below) or an original, first, and joint inventor (if plural inventors are named below or in an attached Declaration) of the subject matter which is claimed and for which a patent is sought on the invention entitled

CORRECTION OF DEFECTIVE PIXELS IN A DETECTOR

(Attorney Docket No. 15-XZ-4974 (70191/195))

the specification of which (check one)

_X_ is attached hereto.

____ was filed on _______ as United States Application Number or PCT International Application Number ______ and was amended on ______ (if applicable).

THAT I do not know and do not believe that the same invention was ever known or used by others in the United States of America, or was patented or described in any printed publication in any country, before I (we) invented it;

THAT I do not know and do not believe that the same invention was patented or described in any printed publication in any country, or in public use or on sale in the United States of America, for more than one year prior to the filing date of this United States application;

THAT I do not know and do not believe that the same invention was first patented or made the subject of an inventor's certificate that issued in any country foreign to the United States of America before the filing date of this United States application if the foreign application was filed by me (us), or by my (our) legal representatives or assigns, more than twelve months (six months for design patents) prior to the filing date of this United States application;

THAT I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment specifically referred to above;

THAT I believe that the above-identified specification contains a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the invention, and sets forth the best mode contemplated by me of carrying out the invention; and

THAT I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I HEREBY CLAIM foreign priority benefits under Title 35, United States Code §119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number	Country	Foreign Filing Date	Priority Claimed?	Certified Copy Attached?

I HEREBY CLAIM the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

U.S. Provisional Application Number	Filing Date

I HEREBY CLAIM the benefit under Title 35, United States Code, §120 of any United States application(s), or § 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Application Number	Parent Filing Date	Parent Patent Number

I HEREBY APPOINT the following registered attorneys and agents of the law firm of FOLEY & LARDNER, Firstar Center, 777 East Wisconsin Avenue, Milwaukee, Wisconsin 53202:

RUSSELL J. BARRON	Reg. No. 29,512
DAVID J. BATES	Reg. No. 39,902
STEVEN C. BECKER	Reg. No. 42,308
DOUGLAS A. BOEHM	Reg. No. 32,014
EDWARD W. BROWN	Reg. No. 22,022
LISA A. BRZYCKI	Reg. No. 40,926
CHARLES G. CARTER	Reg. No. 35,093
ALISTAIR K. CHAN	Reg. No. 44,603
JOHN C. COOPER III	Reg. No. 26,416
JEFFREY N. COSTAKOS	Reg. No. 34,144
WILLIAM J. DICK	Reg. No. 22,205
BARRY L. GROSSMAN	Reg. No. 30,844

PAUL S. HUNTER	Reg. No.	44,787
KATHERINE D. LEE	Reg. No.	44,865
KEITH D. LINDENBAUM	Reg. No.	40,365
RICHARD J. MC KENNA	Reg. No.	35,610
JAMES G. MORROW	Reg. No.	32,505
RICHARD B. O'PLANICK	Reg. No.	29,096
STEPHEN MICHAEL PATTON	Reg. No.	36,235
JOHN T. PIENKOS	Reg. No.	42,997
TODD A. RATHE	Reg. No.	38,276
MICHAEL D. RECHTIN	Reg. No.	30,128
CHRISTOPHER M. TUROSKI	Reg. No.	44,456
PETER J. VOGEL	Reg. No.	41,363
JAMES A. WILKE	Reg. No.	34,279
JOSEPH N. ZIEBERT	Reg. No.	35,421
WALTER E. ZIMMERMAN	Reg. No.	40,883

along with the following registered attorneys and agents of GE MEDICAL SYSTEMS, 3000 North Grandview Boulevard, W-710, Waukesha, Wisconsin 53188:

CHRISTIAN G. CABOU	Reg. No.	35,467
ELAINE H. LO	Reg. No.	41,158
PHYLLIS Y. PRICE	Reg. No.	34,234

along with the following registered attorneys and agents of GENERAL ELECTRIC COMPANY, 3135 Easton Turnpike, W3C, Fairfield, Connecticut 06431:

JAY L. CHASKIN	Reg. No.	24,030
RONALD E. MYRICK	Reg. No.	26,315
HENRY J. POLICINSKI	Reg. No.	26,621

to have full power to prosecute this application and any continuations, divisions, reissues, and reexaminations thereof, to receive the patent, and to transact all business in the United States Patent and Trademark Office connected therewith;

and I request that all correspondence be directed to:

Katherine D. Lee
FOLEY & LARDNER
Firstar Center
777 East Wisconsin Avenue
Milwaukee, Wisconsin 53202-5367

Telephone: (414) 297-5531
Facsimile: (414) 297-4900

I UNDERSTAND AND AGREE THAT the foregoing attorneys and agents appointed by me to prosecute this application do not personally represent me or my legal interests, but instead represent the interests of the legal owner(s) of the invention described in this application.

I FURTHER DECLARE THAT all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the

United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Name of first inventor	Richard Aufrichtig
Residence	Mountain View, CA
Citizenship	Denmark
Post Office Address	1240 Dale Avenue, Apt. 43, Mountain View, CA 94040
Inventor's signature	R. Aufrichtig
Date	December 23, 1999

Name of second inventor	Ping Xue
Residence	Waukesha, WI
Citizenship	P.R. of China
Post Office Address	820 Delafield St., Apt. 25, Waukesha, WI 53188
Inventor's signature	Ping Xue
Date	Dec. 23, 1999

Name of third inventor	Kenneth Scott Kump
Residence	Waukesha, WI
Citizenship	United States of America
Post Office Address	614 Crestwood Drive, Waukesha, WI 53188
Inventor's signature	Kenneth Scott Kump
Date	December 11, 1999